Advanced Fusion Concepts: Neutrons for Testing and Energy

LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

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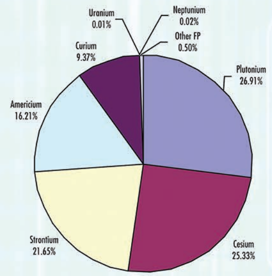
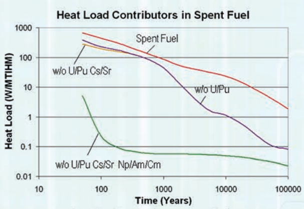
Purpose of Actinide Transmutation

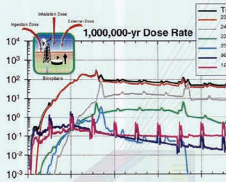


Dominant Heat Producers in Spent Fuel



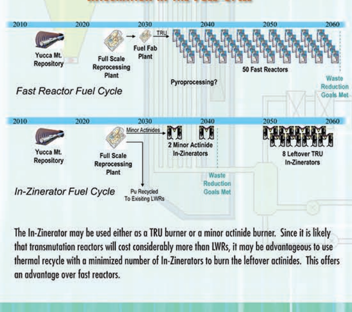
Long-Term Heat Producers in Spent Fuel

The actinides Pu/Np/Am/Cm dominate the long-term heat load and dose rate of the repository, which limits repository capacity. Removal and transmutation of these species can increase repository capacity 50-100X



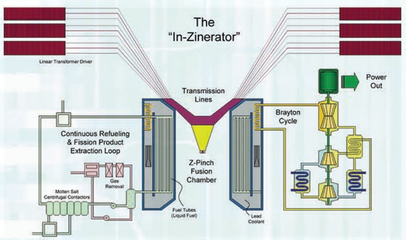
Major Contributors to Dose in the Repository

Integration in the Fuel Cycle



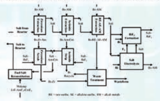
The In-Zinerator may be used either as a TRU burner or a minor actinide burner. Since it is likely that transmutation reactors will cost considerably more than LWRs, it may be advantageous to use thermal recycle with a minimized number of In-Zinerators to burn the leftover actinides. This offers an advantage over fast reactors.

The "In-Zinerator"

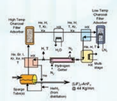


Extraction System Design

The In-Zinerator uses a liquid fuel for continuous refueling, extraction of fission products, and extraction of tritium. The molten salt mixture is a eutectic that allows for high actinide concentrations (LiF)2-AnF3 or (LiF-CsF)2-AnF3. First helium is sparged through the fuel to remove deuterium, tritium, and fission product gases; later the tritium is separated and used to produce the fusion targets. Then the fuel passes through molten salt centrifugal contactors to remove fission products—the concentration in the fuel is kept below 1%. Finally, the fuel is re-constituted with fresh TRU and lithium



Fission Product Separation



Tritium Recovery

Power Plant Parameters

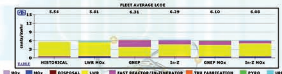
Overall Parameters

Fusion Target Yield	200 MJ
Repetition Rate	0.1 Hz
K_{eff}	0.98
Power per Chamber	3,000 MWth
Energy Multiplication	150
Transmutation Rate	1,280 kg/yr
Chamber Outer Radius	4.1 m
Chamber Material	Hastelloy-N or F82H

RTL Material	Tin
Actinide Mixture	(LiF)2-AnF3
Coolant	Lead
Shock Mitigation	Tin & Argon Aerosol
Coolant Temperature	950 K
Heat Cycle	Brayton
Tritium Breeding Ratio	1.1
Fission Product Removal	On-Line

Economics

The economics of In-Zinerators to burn all TRU produced from existing LWRs is comparable to the use of Fast Reactors, but either option will lead to an increase of 0.2 c/kWh for the reprocessing plant plus 0.5 c/kWh for the reactors



REACTOR COST ASSUMPTIONS

URANIUM COST ($/kg U)	100.00
LWR CAPITAL COST ($/kW)	1,800.00
FAST REACTOR CAPITAL COST ($/kW	2,500.00
In-Zinerator CAPITAL COST ($/kW)	3,000.00

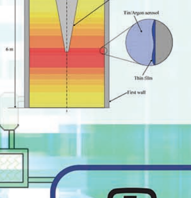
LWR TO FR/IN-Z SUPPORT RATIO

GNEP	2
IN-Z	5
GNEP - MOx	4
IN-Z - MOx	10

FUEL CYCLE COST ASSUMPTIONS ($/kgHM)

DISPOSAL COST (mill/kWh	1.00	
MOx FUEL FAB COST	1,500.00	
UREX REPROCESSING COST	1,000.00	
	FR	IN-Z
TRU FUEL FAB COST	2,600.00	0.00
PYRO REPROCESSING COST	2,000.00	2,000.00

Economics



A tin/argon aerosol is used for shock mitigation and x-ray absorption; molten tin is collected from the bottom of the chamber for remanufacture into a new RTL

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